**NASA Technical Memorandum**



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# IMPROVED TURBOPUMP DYNAMICS

## CENTER DIRECTOR'S DISCRETIONARY FUND FINAL REPORT

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16. ABSTRACT

A study was initiated to investigate the practicality of increasing rotor critical speeds by changes in manufacturing method. The technique would be to build a pump with an all-laser-welded shaft and case; such unit to be opened by laser cutting and rebuilt by rewelding the same surface. Use of a split casing, common in industry, would permit assembly of the rotor outside the case. A team was formed to perform the study; however, the work of the team was severely restricted by conflict with higher priority tasks. No manpower was available to evaluate alternate configurations. Thus, much of the synergetic effects of cohesive design modification was lost. Although very limited results were achieved, nothing was found to indicate that the method is not worth further investigation.

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## INTRODUCTION

Critical speed limitations are among the most serious design restraints for state-of-the-art rocket engine turbomachinery. Increases in critical speeds are highly desirable. Increases in critical speed can be achieved by making the rotor shorter and more rigid.

## APPROACH

Establish feasibility of building a pump with an all-laser-welded shaft and case; such unit to be opened by laser cutting and rebuilt by rewelding the same surface. Use of a split casing, common in industry, would permit assembly of the rotor outside the case. A sacrificial strip would be used to limit cutting damage, and each surface would have protected precision locating surfaces (Fig. 1). Establish a revised pump preliminary design using the existing major fluid handling components but optimizing dynamic characteristics and other components. Determine the performance increases possible in the following areas:

1. Primary

    a. Increase or rotor critical speed
    b. Decrease in rotor damping
    c. Improved balance

2. Secondary

    a. Seal performance improvement
    b. Weight reduction
    c. Performance improvement
    d. Cost reduction (reduced number of machined parts and surfaces).

A team was formed to conduct the study. The SSME HPOTP (high pressure oxygen turbopump) was selected as the target unit.

## RESULTS

The work of the team was severely restricted by conflict with higher priority tasks. No manpower was available to evaluate alternate configurations. Thus, much of the synergetic effects of cohesive design modification was lost.

Structural dynamic modes were calculated for a welded rotor versus the present built-up rotor (Fig. 2) with the same length and external dimensions. A frequency increase of 5 percent was calculated. An increase of this magnitude is not considered significant.

Electron beam welding has been identified as possibly more desirable than laser welding for the applications and a subject for further evaluation.

Further research tasks have been identified to support further development and address key problems. These consist of coupon tests to evaluate the cut and reweld concept and development of distortion minimization techniques.

## CONCLUSION

The goals of this study proved to be beyond the resources of a small team working on a part time basis. Accomplishment will require a diversified, dedicated design team working under guidelines to allow major changes from present design. Implementation of the welding-cutting technique on a piece-wise basis is not practical.

Key problems with the technique have been identified and are being made subject to further research.

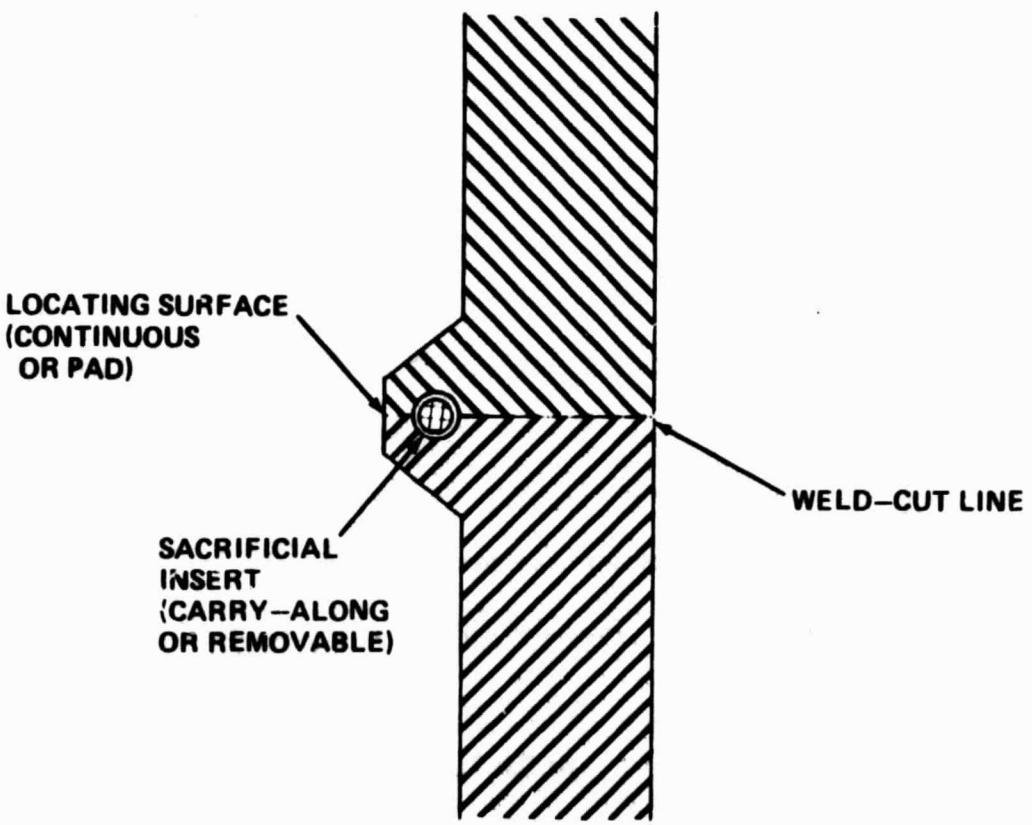


Figure 1. Proposed joint configuration pump construction.

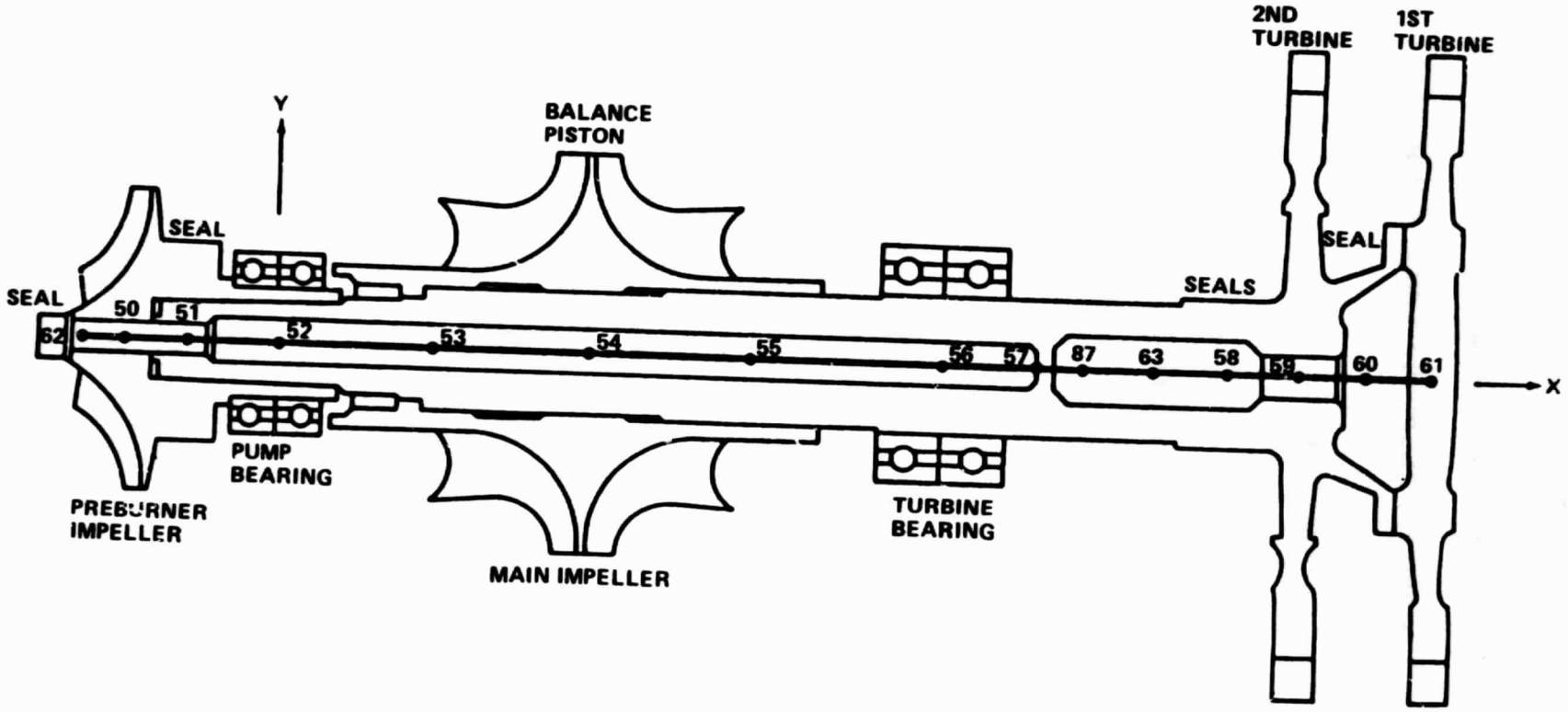


Figure 2. SSME HPOTP rotor and joints on current math model.

## APPROVAL

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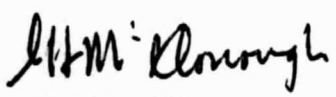
The information in this report has been reviewed for technical content. Review of any information concerning Department of Defense or nuclear energy activities or programs has been made by the MSFC Security Classification Officer. This report, in its entirety, has been determined to be unclassified.



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